REPORT ON THE DRILLING OF AN EXPLORATORY BOREHOLE NEAR STRAWBERRY, ARIZONA
(May 18 – June 2, 2000)

A Hydrogeologic Investigation for the
Northern Gila County Water Plan Alliance

Report Written by

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The drilling of the exploratory borehole near Strawberry, Arizona was accomplished through the cooperation and collective efforts of many organizations and individuals. Gratitude and appreciation is expressed to the following organizations and individuals that played important roles in the funding, planning, drilling, data collection and data analysis phases of this project.

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INTRODUCTION

The Northern Gila County Water Plan Alliance (NGCWPA) was formed to address the increasing need for a firm water supply for the northern Gila County area. Over the past two and one half years many meetings of participants have taken place to discuss and pursue possible answers.

Currently, federal, state and local participants are funding a project by the United States Geological Survey (USGS) to study the surface and subsurface geology in the northern Gila County area. In order to supplement this project, an exploratory borehole was drilled in the Strawberry area to gather information and gain further insight into the deep subsurface geology of the area.

This report describes the drilling of the exploratory borehole, NGCWPA-1 (ADWR well registration number 55-581081), in the vicinity of Strawberry, Arizona during the period May 18 to June 2, 2000. The report provides descriptions of geologic samples and interpretations of hydrogeologic data derived from the geophysical logging of the borehole. Recommendations for future monitoring of the borehole are also provided.

WELL SITE LOCATION

The well site is located one-quarter mile south of Fossil Creek Road and 500 feet north of Strawberry Creek on a Gila County easement about 100 feet east of Juniper and Oak Roads (Figure 1). The Global Positioning System (GPS) coordinates of the well are: Latitude 34° 24' 15.1", Longitude 111° 31' 11.6", or UTM coordinates (NAD27 Zone12 Northing 452,214 Easting 3,806,900). The GPS coordinates were obtained using a hand-held unit with an estimated potential horizontal error of 18 feet (the GPS coordinates were obtained the day after the selective availability of the Precise Positioning Service had been lifted). The cadastral location of the well is (A-12-08) 29aaa.

The GPS determined land surface elevation of the well site is 5,805 feet (above mean sea level). The land surface elevation of the well site was also estimated to be about 5,750 feet from the USGS 7.5 minute topographic map of the Strawberry Quadrangle. For interpretation purposes the land surface elevation of the well site was estimated to be 5,780 feet.

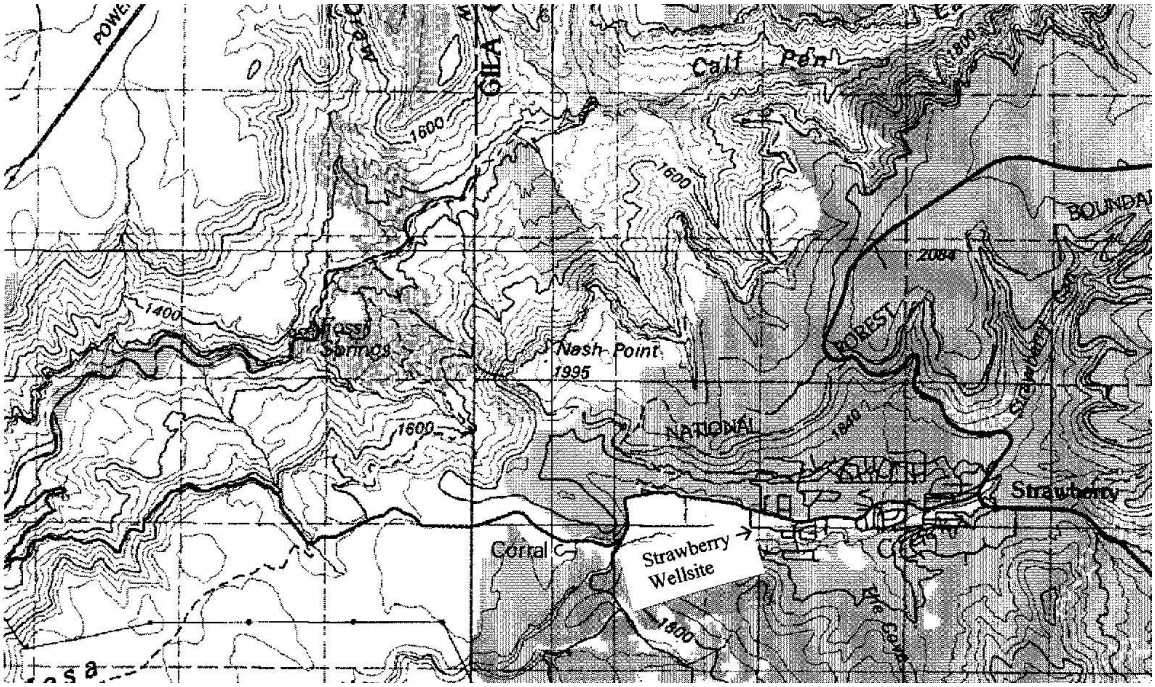


Figure 1 Topographic Map of the Strawberry area

WELL DRILLING AND COMPLETION OPERATIONS

The NGCWPA-1 exploratory borehole was drilled by the Stewart Brothers Drilling Company (Milan, New Mexico). Project supervision and oversight were provided by the NGCWPA. United States Bureau of Reclamation (USBR) personnel served as site geologists during the drilling operations. Technical advice concerning drilling operations and geophysical logging were provided by personnel from the ADWR.

The drilling equipment (Figures 2-4) included: a Failing CF2500 Holemaster (conventional mud/air rotary drilling rig); 6.25 inch tricone roller rockbits; 280 feet of 4.75 inch by 20 foot drill collars; 3.5 inch by 20 foot drill rods; Gardner Denver 5x10 mud pumps; mix pump (for foam); Sullair 900xh 900cfm compressor; a Grimmer Schmidt compressor booster; a mix tank; two 8 by 12 foot mud pits; and two 3,200 gallon water trucks.

Drilling operations began on the Strawberry exploration well on May 18, 2000. The well was drilled using conventional mud rotary techniques from the land surface to a depth of 1,461 feet below land surface (BLS). The drilling fluid was a mixture of water and bentonite. Samples were collected from the flow line using a hand strainer (Figure 5). The drilling mud weight ranged from 8.4 to 8.7 pounds per gallon. The mud funnel viscosity ranged from 35 to 46 seconds.

During drilling operations several zones were encountered where all the drilling fluid drained from the borehole. These “lost circulation” zones corresponded to probable large fractures or cavities. Initially, lost circulation materials were added to the drilling mud to control fluid loss at depths of 415 to 417 feet (BLS) and 645 to 650 feet (BLS). Eventually, it was determined that the fluid loss could not be controlled with standard lost circulation materials, and cement was subsequently pumped into the borehole and allowed to harden for several hours when lost circulation zones were encountered. Cement was tremmied through the drill pipe at depths of 575 to 650 feet (BLS), 645 to 650 feet (BLS), 982 to 983 feet (BLS), 973 to 998 (BLS) and 987 to 1,004 feet (BLS).

Due to fluid loss problems caused by numerous cavities and fractures, no drilling fluid or samples were circulated to the land surface below a depth of 970 feet. Although no drilling fluid or samples were returned to the surface, drilling operations using mud continued to a depth of 1,461 feet. Drilling operations were suspended at a depth of 1,461 feet because of the large fluid loss, and because the local water supplier declined to sell any additional water to the drilling contractor. The fluid loss encountered during the last several hours of drilling was estimated to be about 90,000 gallons.

Drilling was initially suspended on May 25, 2000. Geophysical well logging operations were conducted on May 26, 2000 (Figures 6 and 7). The geophysical well logging operations were conducted by Southwest Geophysical using logging equipment and personnel dispatched from Chandler, Arizona and Farmington, New Mexico. The

logging services that were run included: 16-inch and 64-inch normal and spontaneous potential (E-log), induction electric, compensated density, neutron, natural gamma ray and caliper. Blockage or bridging of the borehole prevented advancing the neutron and induction logging tools below a depth of 900 feet, therefore these logs were only run above that depth. Geophysical well logging operations were witnessed by USBR and ADWR personnel.

After the completion of geophysical logging operations on May 26, 2000 it was decided that further drilling would be attempted using conventional air rotary techniques. The conversion from mud rotary to air rotary was accomplished on May 30, 2000, and air drilling began on May 31, 2000. Drilling activities were terminated due to difficulty in drilling and budgetary considerations on June 1, 2000 at a total depth of 1,872 feet. No samples were returned to the surface during air rotary drilling.

A second set of geophysical well logs were run on the deepened borehole. The geophysical well logging operations were conducted by Southwest Geophysical using logging equipment and personnel dispatched from Chandler, Arizona and Farmington, New Mexico. The logging services that were run included: 16-inch and 64-inch normal and spontaneous potential (E-log), temperature, compensated density, neutron, natural gamma ray and caliper. Blockage or bridging of the borehole prevented advancing any of the logging tools below a depth of 1,773 feet, therefore these logs were only run above that depth. Geophysical well logging operations were witnessed by USBR and ADWR personnel.

Once the final logging was completed 4-inch steel casing was set as deep in the well as borehole conditions allowed. Based on difficulties experienced during drilling, and further difficulties encountered during the preparation of the borehole for running casing it seemed unlikely that the casing could be set to the original total hole depth. As anticipated, borehole bridging and/or sluffing prevented the casing from being advanced below a depth of 1,420 feet (a depth about 40 feet below the static water level in the borehole). The bottom of the 4-inch casing was left open, and the bottom 150 feet (from 1,420 to 1,270 feet) of casing was slotted. A cement basket was set between the outside of the casing and the borehole wall at a depth of 210 to 212 feet to prevent downward seepage from a shallow ground water zone that was encountered at a depth of about 170 feet. The design of the completed borehole is shown in Figure 8.

On June 16, 2000 personnel from the ADWR tapped the well cap to create a water level sounding port and installed a threaded steel plug. The depth to water that was measured on June 16, 2000 was 1,377 feet.

Figure 2 Stewart Brothers Drilling Rig

Figure 3 Mud Pit

Figure 4 Drilling Mud and Lost Circulation Materials

Figure 5 Samples of drill cuttings

Figure 6 Geophysical logging truck

Figure 7 Logging engineer prepares logging tool

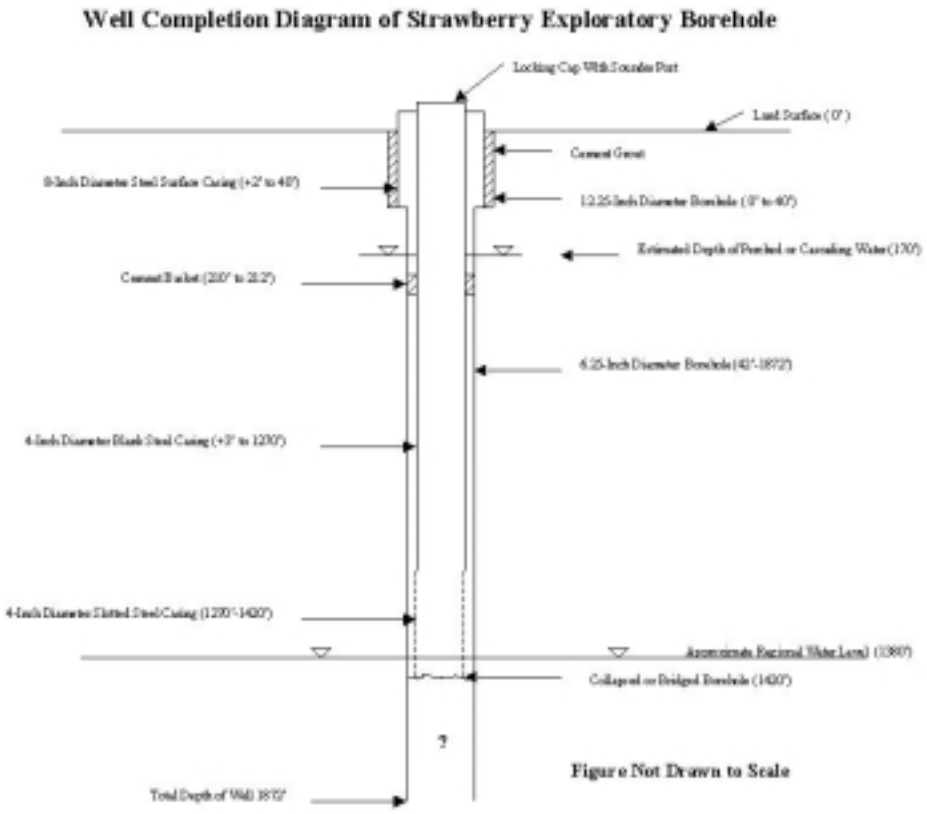


Figure 8 Well design diagram

HYDROGEOLOGIC SETTING OF THE WELL SITE

The Strawberry exploratory borehole is located near the base of the Mogollon Rim, and about three miles southeast of Fossil Springs (Figure 1). The Mogollon Rim, which is the eroded south-southwestern edge of the Colorado Plateau, forms an escarpment that is locally more than 1,000 feet high. Layers of sedimentary rock of Paleozoic age are exposed on the face of the escarpment.

The Paleozoic rocks that may occur at depth, but are not exposed at the land surface in the Fossil Creek-Strawberry area include the Cambrian Tapeats Sandstone, and the Devonian Martin Limestone. Although the Tapeats Sandstone is not exposed in the Strawberry area the Tapeats does outcrop north of Payson at the Highway 87 bridge crossing of the East Verde River. At that location the Tapeats Sandstone is a medium to coarse-grained, moderately cemented, reddish-beige colored sandstone that overlies the Precambrian Payson Granite. In general, the Tapeats Sandstone forms a thin layer which overlies Precambrian basement rocks. The thickness of Cambrian rocks in the northern Gila County area has been mapped by Pierce (1976) to be less than 100 feet.

The Devonian Martin Limestone overlies the Tapeats Sandstone in much of the Payson-Pine-Strawberry area. Although the Martin Formation does not outcrop in the Fossil Creek-Strawberry area it has generally been described in other locations as a dark-colored, dolomitic limestone with disseminated argillaceous and arenaceous material (Kreiger, 1965). The dark color, thinly and evenly bedded character, and steplike slopes to which the formation weathers serve to distinguish it from the overlying Redwall Limestone (Krieger, 1965). The thickness of Devonian rocks in the northern Gila County area has been mapped by Pierce (1976) to range from about 200 to 400 feet.

The Paleozoic sedimentary rocks that are exposed in the Fossil Creek-Strawberry area include rocks that range from Mississippian to Permian age (Figure 9). The Mississippian Redwall Limestone, the oldest exposed sedimentary rocks in the area, is exposed at Fossil Springs in the bottom of the Fossil Creek Canyon. Although the thickness of the Redwall Limestone varies, the exposed thickness at an outcrop on the west side of Fossil Creek is 106 feet (McKee, and Gutshick, 1969). At Fossil Springs, several major springs discharge about 30,000 acre-feet of groundwater per year from fractures, cavities and/or other solution features from outcrops located near the contact between the Redwall Limestone and the overlying Naco Formation (Figures 10-11) (USGS, 1998).

The Pennsylvanian Naco Formation overlies the Redwall Limestone in the Fossil Creek-Strawberry area. The Naco Formation consists of interbedded grayish limestone and limey claystone. The Naco Formation displays many secondary solution and karstic features typical of carbonate rocks. In the Fossil Creek-Strawberry area the Naco Formation is unsaturated. The total thickness of the Naco Formation on the east side of Fossil Creek is about 400 feet (Figure 12).

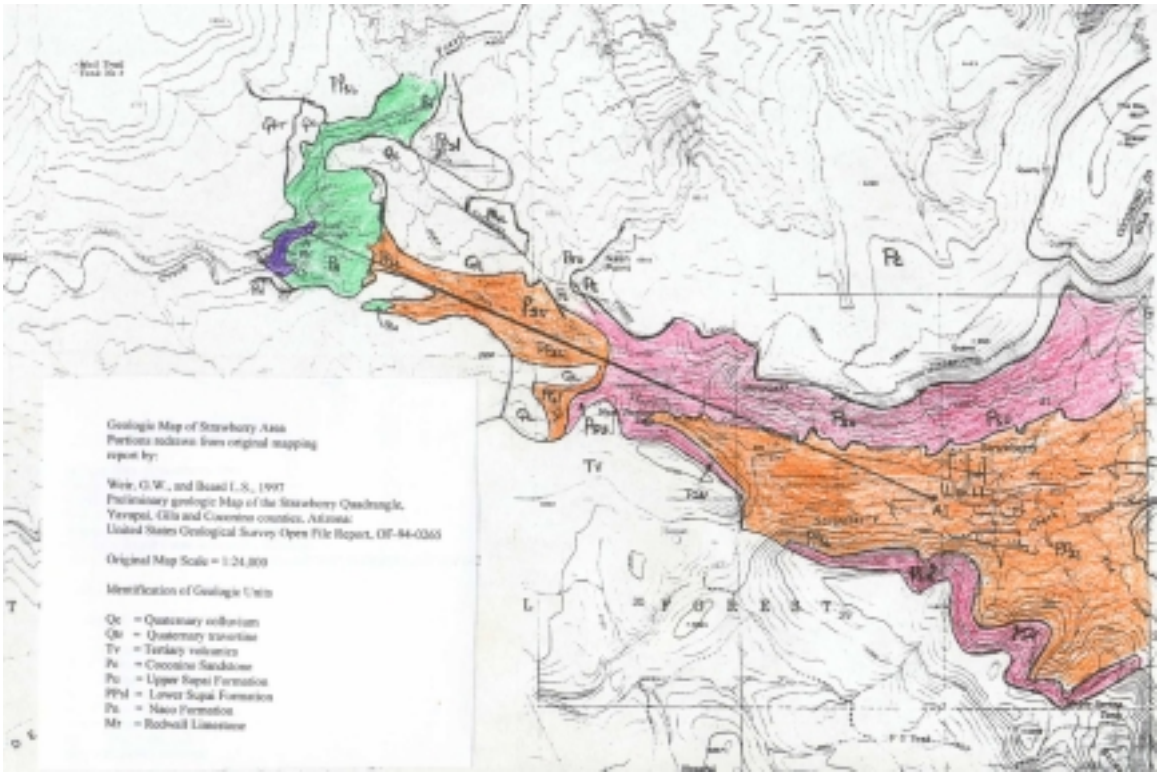


Figure 9 Geologic Map of Strawberry - Fossil Springs area

Figure 10 A major spring at Fossil Springs

Figure 11 Water seeping from a limestone outcrop at Fossil Springs

Figure 12 View to the East toward Strawberry from Fossil Springs

The Naco Formation forms the cliff above Fossil Creek in the foreground. The Lower and Upper Supai Formations are exposed in the background, overlying the Naco. Coconino Sandstone caps the highest cliffs on the horizon.

The Pennsylvanian-Permian Supai Formation overlies the Naco Formation in the Fossil Creek-Strawberry area (Figure 12). In the Fossil Springs-Strawberry area the Supai Formation has been divided into upper and lower members. The Supai Formation consists of mainly red beds, sandstone, siltstone, mudstone with some interbedded limestone. In the Fossil Creek-Strawberry area the Supai Formation may contain water-bearing strata at depths of a few hundred to several hundred feet below land surface. It is believed that these water-bearing strata mainly receive recharge from local surface water drainages. The total thickness of the lower member of the Supai Formation is about 1,000 to 1,100 feet on the east side of Fossil Creek (Figure 12). The lower member of the Supai Formation, which is comprised of mainly red sandstone, siltstone and mudstone is exposed in Strawberry Creek, located just to the south of the Strawberry well site.

The youngest Paleozoic formation that is exposed in the Fossil Creek-Strawberry area is the Permian Coconino Sandstone. The Coconino Sandstone overlies the Supai Formation and is exposed as the upper cliff forming unit that caps the Mogollon Rim north of Strawberry. In that area the Coconino Sandstone is a light yellowish-brown to white colored, fine-grained, poorly to moderately cemented sandstone. In many parts of the Colorado Plateau region the Coconino Sandstone comprises the major regional aquifer. However, in the Strawberry area the Coconino Sandstone appears to lie well above the major regional aquifer system.

ANALYSIS OF DRILL CUTTINGS

Drill samples were collected from the drill fluid return flow line at 10-foot intervals from the land surface to a depth of 970 feet. The drilling contractor bagged the samples, and Bureau of Reclamation geologists provided a preliminary log of the samples that is included as Appendix I of this report. A more detailed analysis of the drill cuttings was later conducted by ADWR personnel (Appendix II). No drilling fluid or samples were recovered below a depth of 970 feet due to lost circulation conditions.

The analysis of the drilling samples indicated that the upper 970 feet of the well penetrated sedimentary rocks that were, in general, typical of the lower member of the Supai Formation. The types of materials that were described in the drill cuttings included: reddish-brown sandstone, siltstone, mudstone, and clay with minor amounts gray limestone.

ANALYSIS OF GEOPHYSICAL LOGS

As mentioned previously, geophysical well logs were run on two separate occasions during the drilling of the exploratory borehole. The logs that were run included: 16-inch and 64-inch normal and spontaneous potential (E-log), induction electric, compensated density, neutron, natural gamma ray, temperature, and caliper. The suite of correlated geophysical logs is shown in Figure 13. Copies of the individual logs are included in Appendix III.

Analysis of the well logs has revealed 5 major lithologic zones that may be reasonably correlated to recognized regional geologic formations or units. For the most part the lithologic zones have been identified by their distinctive electrical resistivity, bulk density, neutron porosity, natural gamma radiation, and caliper log responses (see Figure 13 and Appendix III). The five major zones and their characteristic log responses are listed in Table 1. Correlations to recognized geologic units are included in Table 1 and and graphically depicted in a hydrogeologic cross-section constructed from Fossil Creek to the Strawberry well site (Figure 14).

Table 1

Major Lithologic Zones Identified and Typical Geophysical Well Log Responses for the Strawberry Exploratory Borehole (NGCWPA-1)

Depth Zone (Feet BLS)	Gamma Ray API Units	Resistivity Ω•m	Bulk Density (g/cc)	Neutron API Units	Caliper (Inches) ***	Probable Geological Formation or Unit
0 – 400	80 -120	20 - 35	1.80 – 2.10	3000 - 3200	≈7.00	Unsaturated lower member of the Supai Formation (Red Bed Unit)
400 – 1040	80 - 120	25 – 60 *(400 – 904)	2.20 – 2.35	2400 - 3200	≈7.00 Few washouts	Unsaturated lower member of the Supai Formation
1040 – 1295	80 - 160	NA	NU	2000 - 3400	≈6.25 - >12 Ragged borehole highly washed out	Unsaturated Naco Formation
1295 – 1380	15 - 35	NA	2.20 –2.35	3000-4000	≈6.25 Few washouts	Unsaturated Redwall Limestone
1380 – 1395	15	200 – 3600	2.45	1600	≈6.25	Water level transition zone falls within Redwall Limestone**
1395 –1670	15 – 60	500 - 1000	2.40 –2.60	800-1200	≈6.25 Few washouts	Saturated Redwall Limestone/ Martin Formation ?
1670 – 1773	15 – 35	200 - 400	2.30 – 2.45	400 - 800	≈6.25-11.0 Moderate number of washouts	Saturated Martin Formation?/ Tapeats Sandstone?

Note: Some logging responses are greatly effected by borehole conditions, such as fluid level and borehole diameter. Therefore, differences in logging responses may not be indicative of actual lithologic differences.

* = Actual logged interval for any particular log, if different from depth zone
** = Water level in borehole and aquifer falls within this interval. Some logging responses are transitional due to the effects of the logging tool emerging from fluid
*** = Average borehole diameter. Bit size = 6.25 inches.
NA = Logging data not available
NU = Logging data not useful to interpretation due to highly irregular borehole conditions

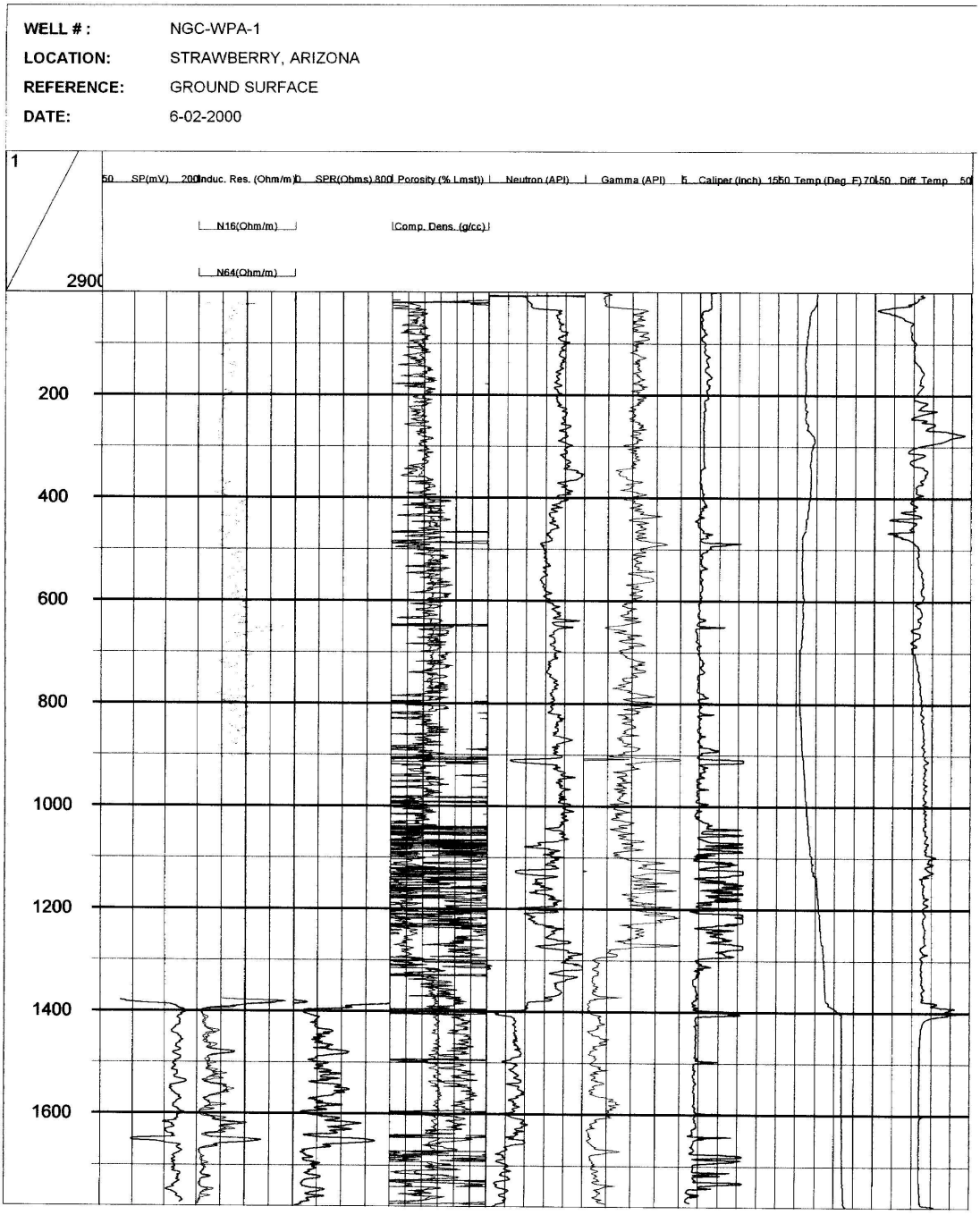
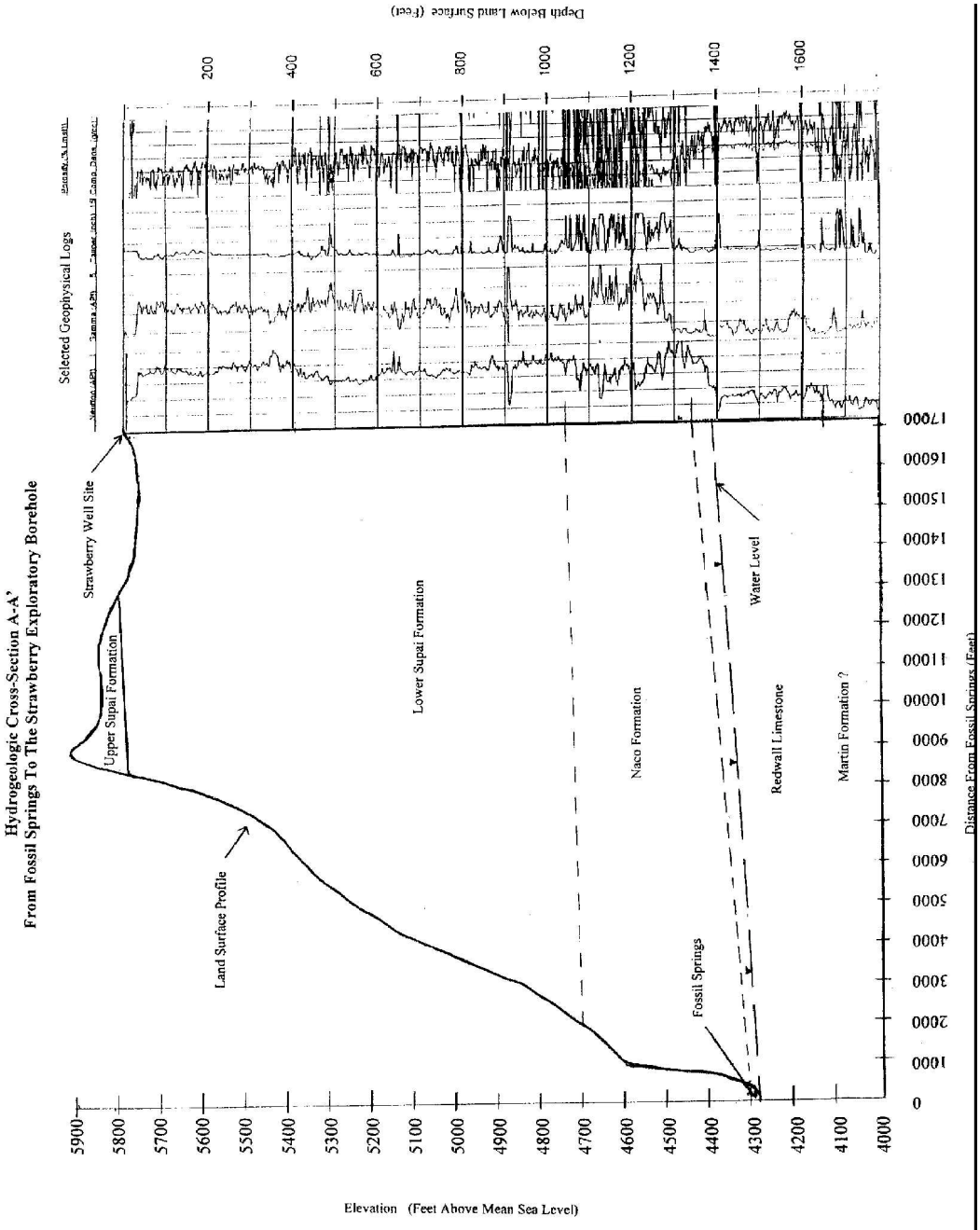


Figure 13 Correlated Geophysical Logs

Figure 14


Hydrogeologic Cross-Section A-A'
From Fossil Springs To The Strawberry Exploratory Borehole
Selected Geophysical Logs
Depth Below Land Surface (Feet)
200
400
600
800
1000
1200
1400
1600
Strawberry Well Site
Upper Supai Formation
Lower Supai Formation
Naco Formation
Redwall Limestone
Martin Formation ?
Water Level
Land Surface Profile
Fossil Springs
5900
5800
5700
5600
5500
5400
5300
5200
5100
5000
4900
4800
4700
4600
4500
4400
4300
4200
4100
4000
Elevation (Feet Above Mean Sea Level)
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Distance From Fossil Springs (Feet)

Summary

An exploratory borehole has been drilled in the Strawberry area to a total depth of 1,872 feet below land surface. Although the total depth of the hole was 1,872 feet, "lost" circulation problems combined with unstable borehole conditions did not allow the collection of drilling samples from depths below 970 feet, and limited the depth of geophysical logs to 1,773 feet.

The major geologic units penetrated by the borehole include the lower member of the Supai Formation, the Naco Formation, the Redwall Limestone, and possibly the Martin Formation and/or the Tapeats Sandstone. A shallow groundwater zone that produced a small, unquantified amount of water into the borehole was encountered in the lower member of the Supai Formation at a depth of about 170 feet. The water level of the regional aquifer system was encountered in the Redwall Limestone at a depth of about 1,380 feet (about 4,400 feet in elevation above mean sea level). Based on interpretation of the geophysical logs it does not appear that basement rock (such as, granite or quartzite) was penetrated by the borehole.

Due to well bridging and/or borehole sluffing it was only possible to run casing down to a depth of 1,420 feet. A cement basket was set between the outside of the casing and the borehole wall at a depth of 210 to 212 feet to prevent downward seepage from a shallow ground water zone that was encountered at a depth of about 170 feet. The basket was filled with cement pumped through a tremmie line.

Recommendations

The following recommendations are being made to provide further information from the Strawberry exploratory borehole, and any other future drilling projects .

1) Obtain the surveyed elevation of the well site.

2) Obtain a water sample from the well to establish base line water quality information. Note! The drilling fluid that was used may still effect water quality, therefore bailing or purging of the well is advised before sampling.

3) Run a video log of the well to determine borehole conditions at the bottom of the well. This information would be valuable if any future attempt is made to cleanout or clear the uncased portion of the borehole.

4) Based on the results of video logging, consider drilling out the bottom uncased portion of the borehole, and run a smaller diameter casing through the 4-inch casing. Note! It is likely that no more than a 2-inch steel or PVC casing could be run through the 4-inch casing to the bottom of the hole.

5) If Recommendation 4 is accomplished run a pump test on the well. However, it is important to realize that due to the small casing diameter and large pumping lift it is questionable whether a small submersible pump, such as the Redi-flo2, could sufficiently stress the aquifer to provide representative test results.

If Recommendation 4 is **not** accomplished, evaluate the possibility of conducting some type of pump test on the well. It is also important to realize that a test on the well in its current state would provide results that would be highly effected by partial penetration, and therefore should be considered only as a last alternative to no testing at all.

6) Continue to monitor water levels and water quality in the borehole on a periodic basis (water levels semi-annually, water quality annually).

7) Potential future exploratory well drilling projects should be planned and coordinated to support the data collection efforts of the USGS Fossil Creek – East Verde River – Tonto Creek study.

8) Alternative drilling methods for any future exploratory boreholes should be carefully chosen to minimize the lost circulation problems encountered during the drilling of the Strawberry borehole.

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Appendix I

USBR Geologist's Notes and Well Log of Strawberry Borehole

GEOLOGIC LOG OF DRILL HOLE NO. NGCWPA-2000-01

SHEET 1 OF 4

FEATURE: Exploratory Borehole
LOCATION: Strawberry, AZ
BEGUN: 5/18/00 FINISHED: 6/2/00
DEPTH AND ELEV OF WATER LEVEL
AND DATE MEASURED: 1380.0 (4400.00) Based on geophysical data

PROJECT: Northern Gila Co. Water Plan Alliance
COORDINATES: N 452,214.0 E 3,806,900.0
TOTAL DEPTH: 1872.0
DEPTH TO BEDROCK: 30

STATE: Arizona
GROUND ELEVATION: 5780.0
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: B. Prudhom, M. Miller
REVIEWED BY:

PURPOSE OF HOLE:
Exploratory hole to characterize Paleozoic stratigraphy and water supply potential; perform geophysical logging and packer water testing; drill to 2500 feet or 10 feet into granitic basement.

DRILL SITE & SET-UP:
On original ground at edge of private apple orchard in Strawberry Valley one-quarter mile south of Fossil Creek Road and 500 feet north of Strawberry Creek on county easement about 100 feet east of Juniper and Oak Roads; GPS coordinates: Latitude 34 24' 15.1" Longitude 111 31' 11.6"; cadastral (A-12-08) 29aaa.

DRILL EQUIPMENT:
Failing CF 2500 Holemaster (conventional mud/air rotary); 6-1/4-in. tricone roller rockbits, 280 feet of 4-3/4-in. by 20-foot-long collar rods, 3-1/2-in. by 20-foot-long pipe rods; Gardner-Denver 5X10 mud pumps, mix pump (for foam); Sullair 900xh 900cfm compressor; Grimmer Schmidt compressor booster; mix tank; two 8 by 12-foot mud pits; two 3,200 gallon water trucks.

WATER TEST EQUIPMENT:
Water tests not performed due to limited budget and concerns about losing packer in caving intervals.

DRILLER:
Stewart Brothers Drilling Co., Milan, NM; F. Pichard (Foreman), R. Salcido & P. Jaramillo (Drillers).

DRILL FLUID:
0.0 - 1461.0 ft.: recirculated water and bentonite mixture.
1461.0 - 1872.0 ft.: SH-1200L acrylamide copolymer mixed with water to form foam.
Lost circulation materials (LCM): Maxi-seal, powdered bentonite, cottonseed hulls, ground paper, Ex-Pando Seal bio- polymer, SH-1200L copolymer.

DRILL FLUID RETURN:

Interval Drilled (ft.)	Est. % Return*
0.0- 415.0	90
415.0- 423.0	0-10
423.0- 645.0	50-80
645.0- 650.0	0
650.0- 730.0	60-70
730.0- 795.0	80-90

DEPTH | GEOLOGIC UNIT / ELEVATION

Alluvium
5750.0

Supai

0 to 30 ft. RECENT ALLUVIUM:

0 to 20 ft. Lean Clay (CL):
Stockpile and cutting samples consist of approx. 100% fines with medium plasticity, no to slow dilatancy, high dry strength and medium toughness; no reaction with HCl. Trace of reddish brown, fine gravel-size fragments of quartzose sandstone; max. size 20 mm; 7-foot deep mudpits composed of homogeneous to blocky lean clay, mostly firm to soft consistency; interpreted as basin fill and overbank/terrace deposits from Strawberry Creek.

20 to 30 ft. Poorly Graded Sand (SP):
Cuttings sample consists of fine- to coarse-sand size, predominantly angular to subrounded fragments of predominantly quartzose sandstone. Trace of volcanic fragments. Variably colored.

30 to 1040 ft. PENNSYLVANIAN-PERMIAN SUPAI FORMATION:
(Based on geophysical logs and regional stratigraphy).

30 to 40 ft. Cuttings sample consists of fine- to coarse-sand size, angular to subrounded, predominantly platy fragments of siltstone/shale; soft, breaks easily with light finger pressure; no reaction with HCl. Moderate reddish brown color.

40 to 340 ft. Cuttings samples consist of fine-sand to fine-gravel size, predominantly platy and angular, to subrounded fragments of fine-grained sandstone to siltstone and shale; soft, breaks easily with light finger pressure; no reaction with HCl. Moderate reddish-brown color. Trace of harder greenish white quartz sandstone fragments.

80 to 90 ft. Cuttings sample similar to 40 to 340 ft. interval plus a trace of coarse-sand size chert fragments.

120 to 130 ft. Cuttings sample similar to 40 to 340 ft. interval plus a trace of calcite occurring as fillings.

140 to 150 ft. Cuttings sample similar to 40 to 340 ft. interval plus one coarse-sand size fragment of calcareous quartz sandstone.

190 to 200 ft. Cuttings sample similar to 140 to 150 ft. interval.

200 to 210 ft. Cuttings sample similar to 40 to 340 ft. interval except fragments of siltstone are predominantly medium- to coarse-sand size, platy, soft. Usually 10% of fragments are fine-gravel size.

260 to 270 ft. Cuttings sample similar to 40 to 340 ft. interval plus a trace of medium-sand size basalt fragments.

340 to 400 ft. Cuttings samples consist of mostly fine- to medium-sand size, predominantly subrounded to subangular,

Continued next page

COMMENTS:

Geologic formation names were chosen based on cuttings samples descriptions (where available), geophysical logging, drilling conditions and regional stratigraphy.

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GEOLOGIC LOG OF DRILL HOLE NO. NGCWPA-2000-01

SHEET 2 OF 4

FEATURE: Exploratory Borehole
LOCATION: Strawberry, AZ
BEGUN: 5/18/00 FINISHED: 6/2/00
DEPTH AND ELEV OF WATER LEVEL
AND DATE MEASURED: 1380.0 (4400.00) Based on geophysical data

PROJECT: Northern Gila Co. Water Plan Alliance
COORDINATES: N 452,214.0 E 3,806,900.0
TOTAL DEPTH: 1872.0
DEPTH TO BEDROCK: 30

STATE: Arizona
GROUND ELEVATION: 5780.0
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: B. Prudhom, M. Miller
REVIEWED BY:

NOTES	DEPTH	GEOLOGIC UNIT / ELEVATION	CLASSIFICATION AND PHYSICAL CONDITION
795.0- 800.0 30 800.0- 850.0 50 850.0- 970.0 30-50 970.0- 1872.0 0 * Site hydrologist **LOST CIRCULATION ZONES:** 415.0- 417.0 ft., sealed with LCM 645.0- 650.0 ft., sealed with LCM and cement 970.0-1197.0 ft. (to 1872.0 ft.), unable to seal **DRILL FLUID COLOR:** Not recorded; visually brown (bentonite color) throughout. **DRILLING METHODS:** Interval Drilled (ft.) Drilling Method 0.0 - 20.0 16-in. solid stem auger 20.0 - 1872.0 6-1/4-in. tricone roller rockbit **DRILLING CONDITIONS/COMMENTS:** Rough drilling/rod chatter at 415.0 feet, lost circulation between 415.0-417.0 feet, tripped out rods, added about 30 bags lost circulation materials (LCM) and regained circulation; drilled smooth using some water to 645 feet; drillstring (rods) dropped and lost all circulation from about 645 to 650 feet in gray, calcareous fine-grained sandstone; tripped out and added about 52 bags LCM and 30 bags bentonite and thickened mud but still no drill fluid return; tripped out and tremmied in 14 bags of Portland cement with 1/4 bag calcium chloride in water (100 gallons) through rods, let set 5 hours; tripped in with bit and drilled back to 650.0 feet but still no fluid return - tremmied another 100 gallons (15 bags cement and 1/2 bag calcium chloride) and let set-up 6 hours, top of cement at 645.5 feet; gurgling and the sound of running water or escaping drill fluid heard in hole; pulled drillstring and measured perched water (on cement) at 273.2 feet, tripped back in, water level inside rods was 232.0 feet; resumed drilling with 60 percent circulation return, mixed another batch of cement (13 bags cement, 1/3 bag calcium chloride) and let set 7 hours, cement level came up to 575 feet sealing off the zone; drilled to 970 feet with about 80 percent return to 743 feet, 30-50 percent return 743 to 970 feet, and no drill fluid or cuttings sample return 970 to 1872 feet (used about 30 percent LCM in drill mud since 650 feet); drilled rough and quick then rods dropped and pressure went to zero 982.0 to 983.0 feet and at 998.0 feet; cemented hole (15 bags cement) 973.0 to 998.0 feet, lost all return again and pressure went from 250 psi to zero after drilling through cement from 999.0 to 1000.0 feet, drilled to 1004.0 feet; cemented interval 987.0 to 1004.0 feet and drilled to 1011.0 feet but no return; interpreted that loss zone was still at 982.0 to 983.0 feet in a fracture	510 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660 670 680 690 700 710 720 730 740 750 760 770 780 790 800 810 820 830 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000 1010 1020 1030 1040 1050 1060	Supai 4740.0 Naco	siltstone fragments. Approx. 80% of the siltstone fragments are moderate reddish-brown in color and have no reaction with HCL. Approx. 20% of the siltstone fragments are light gray in color and have a weak to moderate reaction with HCl. 400 to 410 ft. Cuttings samples consist of predominantly angular to subrounded, medium-sand to very fine-gravel size fragments of greenish gray and moderate brown siltstone and approx. 10% limestone fragments. 410 to 420 ft. Cuttings sample similar to 340 to 400 ft. interval except with more fine-gravel size, predominantly angular and platy fragments. Some fragments of various rock types, one fine-gravel size fragment of fine-grained ferruginous (?) sandstone and a trace of chert. 420 to 440 ft. Cuttings sample consists of approx. 95% very fine-grained sandstone/siltstone and approx. 5% fragments of various rock types (chert, quartz, basalt or gabbro). Fragments are angular to subrounded, medium- to coarse-sand size, predominantly platy; strong reaction with HCl. Moderate reddish-brown in color. 430 to 440 ft. Cuttings sample similar to 420 to 440 ft. interval except only a trace of angular to subangular, chert and ferruginous (?) sandstone fragments. 440 to 450 ft. Cuttings sample consists of approx. 100% angular to subangular, predominantly platy, calcium carbonate cemented siltstone; strong reaction with HCl. 450 to 480 ft. Cuttings sample consists of approx. 95% moderate reddish-brown siltstone and approx. 5% light green siltstone; strong reaction with HCl. 460 to 470 ft. Cuttings sample similar to 450 to 480 ft. interval except trace of light green siltstone and one subrounded, fine-gravel size fragment of ferruginous (?) sandstone. 480 to 530 ft. Cuttings samples consist of approx. 100% medium- to coarse-sand size, angular to subrounded, predominantly subangular and platy (tabular) siltstone and very fine-grained silty sandstone; strong reaction with HCl. Light brown, light grayish brown and moderate reddish-brown in color. 500 to 530 ft. Cuttings sample similar to 480 to 530 ft. interval plus a trace of fine- to medium-grained fragments of various rock types (quartz, chert, mafic and light green siltstone or carbonate). 530 to 540 ft. Cuttings sample similar to 450 to 480 ft. interval with a trace of fine-gravel size fragments of siltstone. Predominantly moderate reddish-brown. 540 to 550 ft. Cuttings sample similar to 480 to 530 ft. interval with a trace of moderate orange pink grains. 550 to 560 ft. Cuttings sample similar to 530 to 540 ft. interval. 560 to 570 ft. Cuttings sample consists of medium- to coarse-sand size and a trace of fine-gravel size moderate reddish-brown siltstone fragments and approx. 40 to 50% grayish brown and greenish brown

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GEOLOGIC LOG OF DRILL HOLE NO. NGCWPA-2000-01

SHEET 3 OF 4

FEATURE: Exploratory Borehole
LOCATION: Strawberry, AZ
BEGUN: 5/18/00 FINISHED: 6/2/00
DEPTH AND ELEV OF WATER LEVEL
AND DATE MEASURED: 1380.0 (4400.00) Based on geophysical data

PROJECT: Northern Gila Co. Water Plan Alliance
COORDINATES: N 452,214.0 E 3,806,900.0
TOTAL DEPTH: 1872.0
DEPTH TO BEDROCK: 30

STATE: Arizona
GROUND ELEVATION: 5780.0
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: B. Prudhom, M. Miller
REVIEWED BY:

NOTES	DEPTH	GEOLOGIC UNIT / ELEVATION	CLASSIFICATION AND PHYSICAL CONDITION
or cavity; drilled blind using lots of water (about 130 gpm- the minimum to cool bit and clean cuttings away) with 16 rod drop intervals (interpreted as solution cavities/voids in the Naco Formation and/or top of Redwall Limestone) between 970 and 1399 feet (see Rod Drop Intervals); drilling rate increased from 1400 to 1418 feet but when adding rod at 1419.0 feet, hole caved about 10 feet on bit, pulled rods and drilled through 10 to 20 feet of cave to 1461.0 feet with continual caving and water loss, source of caved material may be from about 920 feet (from geophysical logging); drilling suspended by ADWR while waiting for geophysical logger to arrive, downhole tool bridged at 920 feet, pulled tool and drillers went back in to clean hole; ran resistivity/SP tool in hole with some sidewall resistance at 1100 feet; determined saturated zone at 1380.0 feet, logged to 1456.0 feet. Drilling resumed May 30 using an air/foam drilling fluid, reamed in an additional 10 feet of 8-inch surface casing to 30.0 feet; encountered cave near the top of the hole and reamed a new bit back to 1461.0 feet; good drill foam return to 850 ft., lost fluid at 850 feet; drilled smoothly but without return at 1542 feet; drilled to 1710 feet with 3 rod drop intervals; drilled harder 1650 to 1660 feet and 1694 to 1703 feet; hole tight with caving around rods at 1729.0 feet, pulled 360 feet of rods and went back in; soft, fast drilling at 1748 feet and at 1768 to 1790 feet; had a 2 foot rod drop 1790.0 to 1792.0 feet, had trouble getting rods past 1790 feet (possibly from caving) but drilled to 1872 feet; terminated hole and geophysically logged hole using E-logs to 1779.0 feet, fluid level again measured at 1380.0 feet; neutron log showed cascading fluid at 170 feet and the temperature log showed no changes 1380 to 1790 feet, could not get induction or sonic probes past 1135.0 feet. **ROD DROP INTERVALS:** RECORDED EST. INTERVAL DISTANCE (ft.) 645.0- 650.0 3-5 982.0- 983.0 0.7 998.0- 999.0 0.7 1041.0-1042.0 1.0 1042.0-1042.5 0.5 1049.0-1051.0 2 1051.0-1053.0 2 1067.0-1071.0 1075.0-1078.0 1083.0-1086.0 1089.0-1090.0 1095.0-1098.0 1125.0-1128.0 1138.0-1141.0 1145.0-1148.0	1070 1080 1090 1100 1110 1120 1130 1140 1150 1160 1170 1180 1190 1200 1210 1220 1230 1240 1250 1260 1270 1280 1290 1300 1310 1320 1330 1340 1350 1360 1370 1380 1390 1400 1410 1420 1430 1440 1450 1460 1470 1480 1490 1500 1510 1520 1530 1540 1550 1560 1570 1580 1590 1600 1610 1620 1630	Naco 4486.0 Redwall	fragments of harder sandstone. Trace of chert and fine-grained conglomeratic sandstone fragments. 570 to 580 ft. Cuttings sample similar to 480 to 530 ft. interval with trace of medium-sand size limestone fragments. 580 to 650 ft. Cuttings sample consists of approx. 70% coarse-sand to trace of fine-gravel size fragments of fine-grained, light gray to light reddish-gray sandstone to siltstone with strong reaction with HCl; approx. 30% mostly medium-sand size fragments of moderate reddish-brown sandstone/siltstone. 600 to 620 ft. Cuttings samples similar to 580 to 650 ft. interval except predominantly subangular fragments of very fine-grained, grayish reddish-brown sandstone. 650 to 680 ft. Cuttings sample consists of approx. 80% medium- to coarse-sand size, predominantly angular to subangular, to subrounded fragments of fine-grained conglomeratic or lithic sandstone (composed of subangular to rounded, fine to medium sand in a matrix of calcium carbonate cemented fines); strong reaction with HCl. Approx. 10% is soft, subrounded fragments of moderate reddish-brown siltstone. Approx. 10% also consists of soft, subrounded fragments of olive green siltstone/claystone; no reaction with HCl. Trace of chert and limestone fragments. Overall, color of interval is grayish red. 660 to 670 ft. Cuttings sample similar to 650 to 680 ft. interval except approx. 65 to 70% conglomeratic sandstone fragments and approx. 20-25% siltstone. 670 to 680 ft. Cuttings sample similar to 660 to 670 ft. interval except 30% reddish brown siltstone fragments plus a few fragments of yellowish (ferruginous ?) quartz arenite and a fine-gravel size fragment of dark dolomite. 680 to 700 ft. Cuttings sample consists of approx. 85% mostly medium- to coarse-sand size, angular to subangular and occasionally subrounded fragments of moderate brown to moderate reddish-brown siltstone; strong reaction with HCl. Approx. 15% greenish-gray sandy limestone and olive green mudstone with a trace of conglomeritic sandstone. 700 to 760 ft. Cuttings samples consist of approx. 90% moderate brown siltstone and silty sandstone fragments and approx. 10% light greenish-gray, sometimes mottled limestone. 710 to 720 ft. Cuttings sample similar to 700 to 760 ft. interval plus a trace of conglomeritic sandstone and olive green siltstone fragments. 720 to 740 ft. Cuttings sample similar to 700 to 760 ft. interval plus a trace of ferruginous (?) sandstone fragments. 740 to 750 ft. Cuttings sample similar to 700 to 760 ft. interval plus a trace of limestone and olive green siltstone/claystone and fine-sand size, subrounded, hard fragments of yellowish claystone; may be caliche; moderate to strong reaction with HCl. 750 to 760 ft. Cuttings sample similar to 700 to 760 ft. interval

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GEOLOGIC LOG OF DRILL HOLE NO. NGCWPA-2000-01

SHEET 4 OF 4

FEATURE: Exploratory Borehole
LOCATION: Strawberry, AZ
BEGUN: 5/18/00 FINISHED: 6/2/00
DEPTH AND ELEV OF WATER LEVEL
AND DATE MEASURED: 1380.0 (4400.00) Based on geophysical data

PROJECT: Northern Gila Co. Water Plan Alliance
COORDINATES: N 452,214.0 E 3,806,900.0
TOTAL DEPTH: 1872.0
DEPTH TO BEDROCK: 30

STATE: Arizona
GROUND ELEVATION: 5780.0
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: B. Prudhom, M. Miller
REVIEWED BY:

NOTES

1157.0-1159.0
1194.0-1197.0
1397.0-1399.0
1597.0-1598.0
1642.0-1644.0
1690.0-1693.0
1790.0-1792.0

CASING AND CEMENTING RECORD:

CS/CM (in.)	Depth (ft.)	Interval Drilled (ft.)
		0.0- 20.0
8-in.	0.0- 20.0	20.0- 650.0
CM	645.0- 650.0	645.0- 650.0
CM	645.5- 650.0	
CM	575.0- 650.0	575.0- 998.0
CM	973.0- 998.0	973.0-1004.0
CM	987.0-1004.0	987.0-1461.0
8-in.	20.0- 30.0	1461.0-1872.0
4-in.	0.0-1420.0	

DEPTH TO WATER DURING DRILLING:

Date (2000)	Depth to Water (ft.)	Hole Depth (ft.)
5/25	1380	1461
6/2	1380	1872

GEOPHYSICAL SURVEY DATA:
Hole geophysically logged on 5/26/00 (T. D. 1461.0 ft.) and on 6/2/00 (T.D 1872.0 ft.) by Southwestern Geophysical Surveys, Inc.; Geophysical tools used: E-log 0-1779 ft.; Dual Density 0-1790 ft.; Caliper 0- 1790 ft.; Induction 0-1456 ft.; Neutron 0-1790 ft.; Gamma 0-1790 ft.; Temperature 1380-1790 ft.; attempted Sonic, but could not get past 1135 ft.. Fluid level was at 1380 ft. for all tests.

SAMPLE DATA:
Cuttings collected by driller every 10 feet and placed in small waxed cloth sample bags from 20.0 to 970 feet; cuttings retained by Arizona Department of Water Resources (ADWR); cutting sample piles photographed. No cuttings sample returned below 970 feet.

HOLE COMPLETION:
Pulled rods; installed approx. 1420 ft. of 4 in. dia. casing; bottom 150 ft. slotted; welded cap on surface casing.

REASON FOR HOLE TERMINATION:
Drilling problems and budget limitations precluded drilling to 2500 feet or into granite basement rock; reached an adequate depth of 1872 feet.

ESTIMATED DRILLING TIME:

12-HR. Shifts	
Set-Up	1.0
Drilling	21.5
Down	0.5

DEPTH | GEOLOGIC UNIT / ELEVATION

1640 1650 1660 1670 1680 1690 1700 1710 1720 1730 1740 1750 1760 1770 1780 1790 1800 1810 1820 1830 1840 1850 1860 1870

Redwall
4110.0

Martin?

3908.0
BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

except trace of limestone.

760 to 800 ft. Cuttings sample consists of approx. 95% predominantly medium-sand size, angular to subangular fragments of moderate brown siltstone and 5% olive green siltstone and dark limestone.

800 to 850 ft. Cuttings sample consists of approx. 85% moderate brown siltstone/silty sandstone fragments, 15% light grayish green limestone fragments, a trace of yellowish beige and ferruginous (?) sandstone, and a trace of hard limestone fragments; strong reaction with HCl. Note: A large amount of lost circulation material (LCM) seen in samples from about 800 feet.

830 to 840 ft. Cuttings sample similar to 800 to 850 ft. interval plus a trace of chert and calcium carbonate fragments.

850 to 870 ft. Cuttings samples consist predominantly of medium- to coarse-sand size, moderate brown silty sandstone and siltstone fragments; approx. 5% fine- to medium-sand size, light green limestone fragments, trace to 5% medium- to coarse-sand size, variable-colored fragments of clean sandstone and chert; no reaction with HCl.

870 to 970 ft. Cuttings samples consist of approx. 70% predominantly moderate brown, very fine-grained sandstone, silty sandstone, and siltstone fragments; approx. 30% medium-sand to trace of fine-gravel size, angular to subrounded, light greenish-gray limestone fragments and trace of chert and yellow orange ferruginous (?) sandstone fragments; moderate to strong reaction with HCl.

890 to 900 ft. Cuttings sample similar to 870 to 970 ft. interval plus several medium-sand size fragments of basalt.

900 to 920 ft. Cuttings samples similar to 870 to 970 ft. interval except 40% light greenish-gray, silty limestone fragments, no chert or volcanics, and one coarse-sand size fragment of soft, yellowish sandstone; weak to no reaction with HCl.

920 to 970 ft. Cuttings samples similar to 900 to 920 ft. interval except approx. 30% light greenish-gray limestone fragments.

1040 to 1294 ft. NACO FORMATION:
(Based on geophysical logs and regional stratigraphy).

No cuttings sample returned.

1294 to 1670 ft. REDWALL FORMATION
(Based on geophysical logs and regional stratigraphy).

No cuttings sample returned.

1670 TO 1872 ft. MARTIN (?) FORMATION
(Based on geophysical logs and regional stratigraphy).

No cuttings sample returned.

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APPENDIX II

ADWR Sample Log of Strawberry Borehole

DEPTH	Percent Lithic Fragments	Maximum Fragment Size	% SS Frags	SS Color	SS Texture	% LS Frags	LS Color	% MS/STS Frags	MS/STS Color	Frag. Acid Reaction	Percent Fines	DESCRIPTION
0-10	3%	5mm	15%	Brown	Fine	15%	Red/Grey	70%	Red	M	97%	97% R/B Fines
10-20	0%					0%				No react	100%	100% R/B Fines
20-30	50%	10mm	60%	Buff	Fine	0%		40%	R/B	No react	50%	Gravelly silt w/ sandstone&mudstone gravel
30 - 40	50%	8mm	5%	Buff	Fine	0%		95%	R/B	No react	50%	R/B mudstone with no HCl rxn
40 - 50	50%	1.2cm	0%			0%		100%	R/B	No react	50%	R/B mudstone
50 - 60	50%	1.2cm	0%			0%		100%	R/B	No react	50%	R/B mudstone
60 - 70	75%	23mm	5%	Buff	Fine	0%		95%	R/B		25%	
70 - 80	65%	14mm	0%			0%		100%	R/B	M-S	35%	R/B mudstone
80 - 90	50%	15mm	0%			0%		100%	Buff-Grey	M	50%	5% mudstone/siltstone buff-grey
90-100	50%	15mm	0%			0%		100%	Buff-Grey	M	50%	5% mudstone/siltstone buff-grey
100-110	40%	6mm	0%			0%		100%	Light Grey	No react	60%	Brown mudstone fragments
110-120	60%	10mm	0%			0%		100%	Light Grey	M	40%	Brown with light grey siltstone lithics
120-130	60%	14mm	0%			0%		100%	Brown	W-M	40%	Brown with some light grey inclusions
130-140	50%	7mm	0%			0%		100%	Brown	W	50%	Brown
140-150	50%	10mm	0%			0%		100%	Lt brown	M-S	50%	Brown with traces of white carbonate lithicfragments
150-160	65%	15mm	0%			0%		100%	Lt brown	W-M	35%	Soft lt brown mudstone
160-170	70%	10mm	0%			0%		100%	Lt brown	M	30%	Limey mud/silt stone
180-190	80%	2mm	0%			0%		100%	Lt brown	M	20%	Brown with traces of calcareous inclusions
190-200	50%	12mm	0%			0%		100%	Lt brown	S	50%	Brown with traces of calcareous inclusions
200-210	50%	5mm	0%			0%		100%	B/G	S	50%	Brown grey with 50% calcareous lithic fragments
210-220	80%	10mm	0%			0%		100%	R/B	M-S	20%	Mudstone with carbonate inclusions
220-230	85%	8mm	0%			0%		100%	Lt brown	S	15%	Mudstone with carbonate inclusions
230-240	0%	0	0%			0%		0%		S	100%	mud with carbonate inclusions
240-250	0%	0	0%			0%		0%		M-S	100%	mud with carbonate inclusions
250-260	0%	0	0%			0%		0%		M-S	100%	mud with carbonate inclusions, inclusions larger than 230-250
260-270	3%	14mm	100%	Buff	Fine	0%		0%		M-S	97%	mudstone with gravel size ss
270-280	0%	0	0%			0%		0%		M	100%	mud with carbonate
280-290	0%	0	0%			0%		0%		S	100%	mud fines, more coarse than 270-280, less ca cement
290-300	0%	0	0%			0%		0%		M	100%	mud fines with few carbonate inclusions

DEPTH	Percent Lithic Fragments	Maximum Fragment Size	% SS Frags	SS Color	SS Texture	% LS Frags	LS Color	% MS/STS Frags	MS/STS Color	Frag. Acid Reaction	Percent Fines	DESCRIPTION
300-310	1%	12mm	0%			0%		100%	dk grey	W	99%	highly mud fines,
310-320	0%	0	0%			0%		0%		W	100%	mud fines, less hard than 310-320, no carbonate inclusions
320-330	4%	10mm	0%			0%		100%	red	M	96%	mud fines w/calcareous inclusions and one siltstone fragment
330-340	0%	0	0%			0%		0%		M	100%	mud fines w/few calcareous inclusions
340-350	4%	10mm	0%			0%		100%	R/B	M-S	96%	mud fines w/calcareous inclusions
350-360	10%	10mm	0%			20%	grey/green	80%	brown	M-S	90%	mud fines w/many calcareous inclusions w/ms & ls frags
360-370	0%	0	0%			0%		0%		M	100%	mud fines w/few calcareous inclusions
370-380	5%	5mm	0%			50%	lt grey	50%	R/B	M-S	95%	mud fines w/many calcareous inclusions up to 2mm
380-390	0%	0	0%			0%		0%		M	100%	mud fines w/moderate amount of calcareous inclusions
390-400	5%	10mm	0%			100%	lt grey	0%		M-S	95%	mud fines w/ large lithic fragments of limestone
400-410	80%	8mm	0%			13%	grey/green	87%	Brown	M	20%	mudstone and limestone litho fragments up to small gravel size
410-420	80%	13mm	0%			75%	green-red	25%	R/B	S	20%	mudstone composed of calcareous grains
420-430	90%	13mm	10%	lt yellow	Fine	5%	grey	95%	Brown	W-M	10%	mudstone with few quartzose and limestone fragments
430-440	95%	15mm	0%			20%	grey	80%	Dk. R/B	S	5%	Primarily calcareous Mudstone
440-450	95%	10mm	5%	Buff	Fine	5%	grey	95%	R/B	S	5%	Calcareous Mudstone with traces of quartzose sandstone and limestone
450-460	95%	13mm	0%			10%	grey	90%	R/B	S	5%	Calcareous Mudstone
460-470	95%	13mm	0%			10%	grey	90%	R/B	S	5%	Calcareous Mudstone
470-480	90%	14mm	0%			33%	grey	67%	R/B	S	10%	Calcareous Mudstone
480-490	90%	10mm	0%			11%	grey	89%	R/B	W-M	10%	Mudstone
490-500	75%	11mm	0%			40%	dk. Grey	60%	R/B	M	25%	Calcareous Mudstone
500-510	75%	15mm	0%			5%	lt grey	95%	R/B	S	25%	Calcareous Mudstone with mafic pieces
510-520	80%	11mm	0%			5%	lt grey	95%	R/B	S	20%	Calcareous Mudstone
520-530	80%	14mm	0%			5%	lt grey	95%	R/B	M-S	20%	Calcareous Mudstone
530-540	80%	14mm	0%			5%	lt grey	95%	R/B	M-S	20%	Calcareous Mudstone
540-550	50%	9mm	0%			50%	lt grey	50%	R/B	M-S	50%	sm litho fragments and calcareous inclusions
550-560	20%	5mm	0%			5%	lt grey	95%	R/B	M-S	80%	sm litho fragments and calcareous inclusions
560-570	20%	9mm	0%			33%	lt grey	66%	R/B	S	80%	mudstone w/many white powdery calcareous inclusions
570-580	20%	6mm	0%			50%	grey/green	50%	R/B	M-S	80%	mudstone w/many white powdery calcareous inclusions

DEPTH	Percent Lithic Fragments	Maximum Fragment Size	% SS Frags	SS Color	SS Texture	% LS Frags	LS Color	% MS/STS Frags	MS/STS Color	Frag. Acid Reaction	Percent Fines	DESCRIPTION
580-590	50%	10mm	80%	grey-brown	Fine	0%		20%	Brown	M	50%	platey ss/cong w/sand size calcareous grains+2 calcite crystal clusters
590-600	50%	12mm	80%	grey-brown	Fine	0%		20%	R/B	S	50%	platey sandstone/conglomerate consisting of sand size calcareous grains
600-610	60%	8mm	80%	grey-brown	Fine	0%		20%	R/B	M-S	40%	w/angular to subangular ss pieces, calcareous inclusions
610-620	60%	12mm	80%	grey-brown	Fine	5%	Green	15%	R/B	M-S	40%	w/angular to subangular ss pieces, calcareous inclusions
620-630	80%	10mm	90%	lt grey	Fine	0%		10%	R/B	M-S	20%	ss fragments in sandy matrix
630-640	80%	10mm	90%	lt grey	Fine	5%	grey/green	5%	R/B	M-W	20%	ss fragments in sandy matrix, with few ss & mudstone fragments
640-650	90%	10mm	100%	lt grey	Fine	0%		0%		M-W	10%	ss fragments in sandy matrix
650-660	90%	6mm	100%	grey-brown	Fine	0%		0%		W	10%	same as 630-650 w/smaller lithic fragments
660-670	95%	15mm%	95%	lt grey	Fine	0%		5%	Brown	W	5%	same as 630-650 w/smaller lithic fragments
670-680	95%	12mm	95%	grey/brown	Fine	0%		5%	Brown	W	5%	calcareous mudstone and ss
680-690	85%	15mm	85%	grey/brown	Fine	5%	grey/green10%	10%	Brown	M-W	15%	small fragments primarily ss w/few mudstone % ls fragments
690-700	95%	12mm	85%	Brown	Fine	10%	lt grey-green	5%	Brown	M-W	5%	small fragments primarily ss w/few mudstone % ls fragments
700-710	90%	14mm	45%	Brown	Fine	10%	green/grey	45%	R/B	W-M	10%	Gravelly size fragments of silty sandstone with pieces of limestone
710-720	90%	12mm	95%	R/B	Fine	5%	grey	0%		W	10%	Angular to sub-angular sandstone with a few limestone fragments
720-730	100%	11mm	100%	grey/brown	Fine	0%		0%		W	0%	Sub-angular sandstone
730-740	90%	13mm	70%	Brown	Fine	30%	white/red	0%		M-W	10%	Sub-angular sandstone w/ls fragments
740-750	95%	12mm	100%	Brown/ Red	Fine	0%		0%		M	5%	Sub-angular fine grain sandstone
750-760	100%	13mm	100%	Brown	Fine	0%		0%		W	0%	Sub-angular sandstone with a trace of limestone fragments
760-770	80%	10mm	0%			5%	lt brown	95%	B/G	M-S	20%	Primarily calcareous Mudstone
770-780	90%	10mm	0%			5%	grey/brown	95%	Brown	W	10%	Mudstone
780-790	90%	8mm	0%			5%	grey/brown	95%	Brown	M-S	10%	smaller lithic fragments than 770-780, calcareous mudstone
790-800	90%	8mm	0%			5%	grey/brow	95%	Brown	M-S	10%	same as 780-790
800-810	90%	12mm	0%			15%	grey	85%	grey/R/B	S	10%	mudstone w/ls lithic fragments
810-820	90%	12mm	5%	Buff	Fine	10%	grey/brown	85%	R/B	M-S	10%	mudstone w/few ls fragments
820-830	90%	8mm	5%	Buff	Fine	10%	grey/brown	85%	R/B	M-S	10%	mudstone w/few ls and ss fragments

DEPTH	Percent Lithic Fragments	Maximum Fragment Size	% SS Frags	SS Color	SS Texture	% LS Frags	LS Color	% MS/STS Frags	MS/STS Color	Frag. Acid Reaction	Percent Fines	DESCRIPTION
830-840	70%	14mm	5%	Brown	Fine	30%	Red/Grey/Brown	60%	R/B/Grey	M-S	30%	calcareous mudstone
840-850	70%	7mm	0%			40%	R/B/Grey	60%	R/B	M-S	30%	calcareous mudstone
850-860	100%	8mm	5%	yellow	Medium	10%	R/B/Grey	85%	R/B	M	0%	calcareous mudstone w/few quartzose ss lithic fragments
860-870	100%	11mm	5%	yellow	Medium	20%	R/B/Grey	75%	R/B	M	0%	calcareous mudstone w/few quartzose ss lithic fragments & ls fragments
870-880	100%	13mm	0%			10%	lt grey	90%	B/G	M	0%	calcareous mudstone
880-890	100%	13mm	0%			20%	grey/red	80%	R/B	M	0%	calcareous mudstone w/trace of quartzose fragments and few ls fragments
890-900	100%	9mm	0%			20%	grey/red	80%	R/B	M	0%	calcareous mudstone w/few ls fragments
900-910	100%	8 mm	0%			10%	lt grey	90%	R/B	M	0%	calcareous mudstone
910-920	100%	11mm	0%			10%	lt grey	90%	R/B	M	0%	calcareous mudstone
920-930	100%	8mm	0%			20%	lt grey/Brown	80%	R/B	M-S	0%	calcareous mudstone
930-940	95%	8mm	0%			0%		100%	R/B	W	5%	mudstone
940-950	100%	8mm	0%			10%	lt grey	90%	R/B	M	0%	mudstone
950-960	100%	14mm	0%			20%	grey/R/B	80%	R/B	M	0%	calcareous mudstone w/few ls fragments

Acid Reaction :

W = weak
M = medium
S = strong

Color: R/B = Red/Brown
G/B = Grey/Brown

Lithology : SS=Sandstone
LS=Limestone
STS=Siltstone
MS=Mudstone